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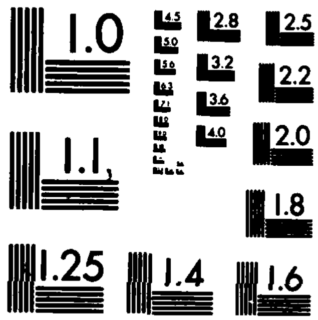

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FOREIGN TECHNOLOGY DIVISION

RECOMBINING PHOTODISSOCIATION IBr LASER IN A PULSE-REPETITION MODE

by

V. A. Dudkin, I. N. Knyazev and V. I. Malyshev

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

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RECOMBINING PHOTODISSOCIATION IBr
LASER IN A PULSE-REPETITION MODE

V. A. Dudkin, I. N. Knyazev, and
V. I. Malyshev.

In the majority of the gas lasers described in the literature, for example [1-6], which are excited during the photodissociation of molecules, the decomposition processes are irreversible and, for this reason, such systems are in essence single-shot lasers. The necessity of removing the decomposition products from the working cell and filling it with the initial product hampers the use of such lasers for physical studies. Thus, of considerable practical interest is a laser with such a working material, whose decomposition products are capable of recombining quickly into the original state. Such substances make it possible to achieve a periodical (and, in principle, also continuous) operating mode of a laser with a sealed-off cell.

Works [7 and 8] were the first to deal with the recombining photodissociation lasers, which employed NOCl [7] and IBr [8] as the initial material. In the first case the photodissociation of the NOCl molecules led to the formation of an inverse population of the NO molecules, while in the second - Br atoms. However, the authors of these works studied these lasers virtually only in a single-pulse mode. This work presents the results obtained from a study conducted on the operation of a IBr laser under the conditions of relatively low repetition frequencies of the illumination pulses; however, in this case, certain new peculiarities appeared in the laser operation which make it possible to draw a conclusion regarding the recombination processes in such a laser.

The mechanism involved in the formation of an inverse population of the Br atoms is analogous to that involved in the creation of the inversion in a CF_3I laser [1], where the transition of an atomic iodide is used. During the photodissociation of an IBr molecule, the formation of an excited Br atom occurs as follows:

$$IBr + h\nu \rightarrow I + Br(P_{1/2}).$$

The maximum of the corresponding absorption band of the IBr molecules lies in the 5000 Å region. Inversion occurs between the levels of a thin structure of the electronic Br therm, which corresponds to the ground state of the atom. A magnetic dipole transition, whose probability is $A \approx 1\ s^{-1}$, is possible between these levels - $P_{1/2}$ and $P_{1/2}$. The transition wavelength $\lambda = 2.714\ \mu m$.

The experimental device had the following parameters. A glass cuvette 110 cm long with an internal diameter of 2 cm was placed inside the cavity which was 140 cm in length. The end windows of the cuvette consisted of quartz and were at the Brewster angle to the axis of the cuvette. The vapor pressure of the substance in the cuvette corresponded to the saturation vapor pressure of IBr, which was 5-6 torr at room temperature ($T=20°C$). One of the cavity's mirrors with the curvature radius $R=500$ cm had a silver coating and was virtually impervious to laser radiation. The other (plane) mirror had a gold coating on a fluorite backing with the transmission of the deposited layer $T \approx 1\%$ at $\lambda = 2.7\ \mu m$. The laser radiation passing through the plane mirror was registered by the Ge—Au photoresistance with the time constant $\tau < 1\ \mu s$. The signal of the illumination pulse was registered by the FEK-09 photoelement.

Two IFP-20,000 lamps were used for the illumination of the cuvette, which were located alongside the cuvette. The cuvette and lamps were wrapped in aluminum foil. The power source for the lamps was a tank $C=2$ mF; the charging voltage varied from 15 to 30 kV; the repetition period of the illumination pulses was 6-7 s.

The energy output in the lasing pulse was determined by a graduated thermopile.

The oscillograms of the illumination and lasing pulses were plotted on the OK-17 oscillograph. Fig. 1 shows a typical form of these oscillograms. Under our conditions, the half-width of the illumination pulse was 8-10 μs and the duration of the lasing pulse - 4-5 μs.

Generation occurred at the leading edge of the illumination pulse virtually in all cases; in this case, the shape and duration of the pulse were only slightly affected by the magnitude of pumping energy.

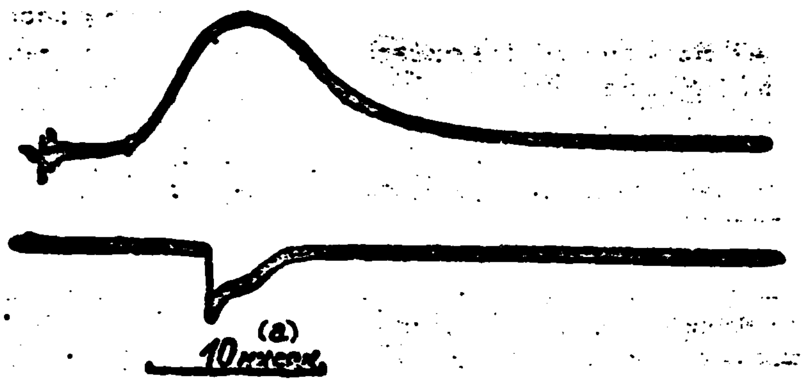


Fig.1. Oscillogram of the illumination and generation pulses.
KEY: (a) μs

A steady decrease in the energy of the generation pulse was observed when the laser operated using the same material in a closed cuvette in the pulse-repetition mode. The data shown in Fig. 2 are the values of the output energy which were averaged over 5 pulses. In addition, it shows the temperature of the cuvette at the beginning of the experiment, after 10 pulses, and after 55 pulses. The amount of output energy increased to its previous level after the cuvette cooled.

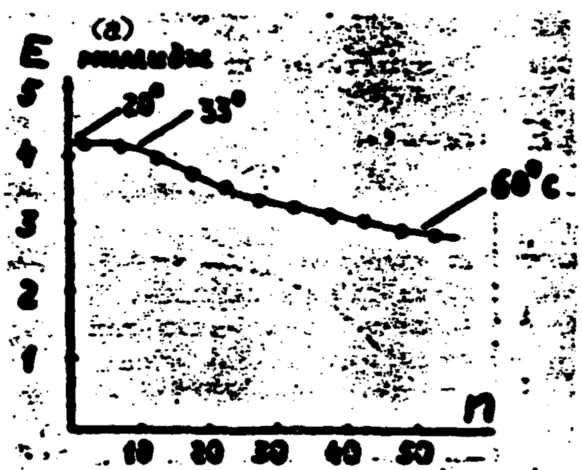
Thus, the rise in the temperature of the cuvette from 20°C to 60°C can somehow be connected with the energy decrease in the lasing pulse by 25-30%. However, according to the data available in the literature [9], there is only a slight dependence of the thermal dissociation of gaseous IBr on temperature in the 20–100°C range (8–13%); thus, apparently, the observed dependence cannot be explained by the increase in the degree of dissociation of the IBr with temperature.

It is possible that the energy decrease in the lasing pulse is connected with a periodic operating mode of the laser, if one assumes that IBr does not recombine completely by the time the next pumping pulse appears. It would seem that this supposition is in contradiction with the data on the recombination time of IBr ($\tau \approx 3 \cdot 10^{-3}$ s) given in work [8]. However, if we examine the procedure used by the authors of [8] to determine the concentration of IBr in the cuvette, then it is pos-

sible to make a conclusion only regarding the fact that a sufficiently high concentration of molecules, which absorb the radiation of an argon laser at λ=5145 Å, appears in the cuvette in a period of time lasting $3-4 \cdot 10^{-3}$ s. The absorption bands of the I_2 and Br_2 molecules are also in this region, as indicated by the authors themselves, and the absorption sections are such that the recombination of the I_2 and Br_2 molecules of the type

$$I_2 + Br_2 \rightleftarrows 2IBr$$

does not lead to noticeable changes in the absorption line.



KEY: (a) mJ

Fig. 2. Dependence of output energy on the number of pulses.

Q=900 J, period - 7 s.

On the basis of this, it is possible to assume that the recombination process of IBr in the cuvette occurs in two stages. During the first stage the I and Br atoms form the IBr, I_2, and Br_2 molecules in a short periods of time. During the second stage, the process wherein the IBr molecules are formed from I_2 and Br_2 occurs more slowly. With a more or less frequent repetition of the illumination pulses, the concentration of IBr can diminish noticeably due to an increase in the concentration of I_2 and Br_2. We note that the increase in the temperature of the cuvette prevents the settling of I_2 onto the sides of the cuvette. Furthermore, the increase in the concentration of I_2 and Br_2 can increase the extinguishing effect on the excited Br atoms.

Even though the IBr recombination mechanism described above makes it possible to offer a qualitative explanation of the observed decrease

in energy, however, it itself is in need of a more thorough study for substantiation.

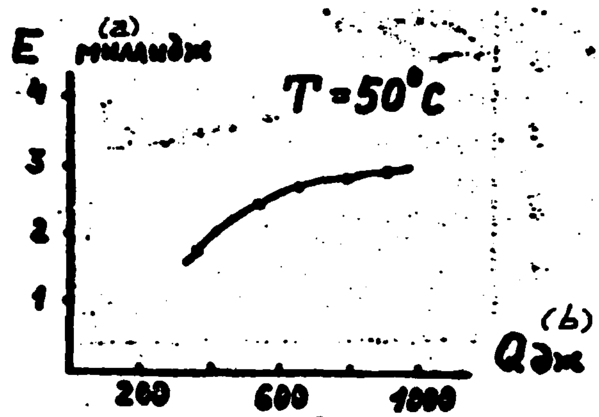


Fig. 3. Dependence of output energy on pumping.

KEY: (a) mJ (b) J

During the experiments we also plotted the output energy as a function of pumping energy for a cuvette heated to 50°C (see Fig. 3). This dependence is similar to that observed in work [8], where the cuvette was at room temperature. With the pumping energies of the order of 1000 J the dependence curve proceeds to saturation.

The maximum energy in the lasing pulse, obtained with the pumping energy at 900 J, was $3{-}4 \cdot 10^{-3}$ J. With a duration of the lasing pulse at 4–5 μs, a value of the order of 1 kW is obtained for the peak output power. Apparently this figure can be increased by optimizing the parameters of the laser - such as the transmission factor of the mirrors, pressure of IBr, etc.

In conclusion the authors express their appreciation to L. A. Novikova and L. V. Morozova for the preparation of IBr.

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Bibliography

1. J. V. V. Kasper, G. C. Pimentel. APL 5, 231 (1964).

2. J. V. V. Kasper, G. C. Pimentel. PRL 14, 352 (1965).

3. M. A. Pollack. APL 8, 237 (1966).

4. M. A. Pollack. APL 9, 94, 230 (1966).

5. J. R. Airey. J. Quant. Electron. 3, 208 (1967).

6. K. L. Kompa, G. C. Pimentel. J. Chem. Phys. 47, 857 (1967).

7. C. R. Giuliano, L. D. Hess. J. Appl. Phys. 38, 4451 (1967).

8. C. R. Giuliano, L. D. Hess. J. Appl. Phys. 40, 2428 (1969).

9. Ya. A. Fialkov. "Interhaloid compounds", Pub. AS UkSSR, Kiev, 1958.